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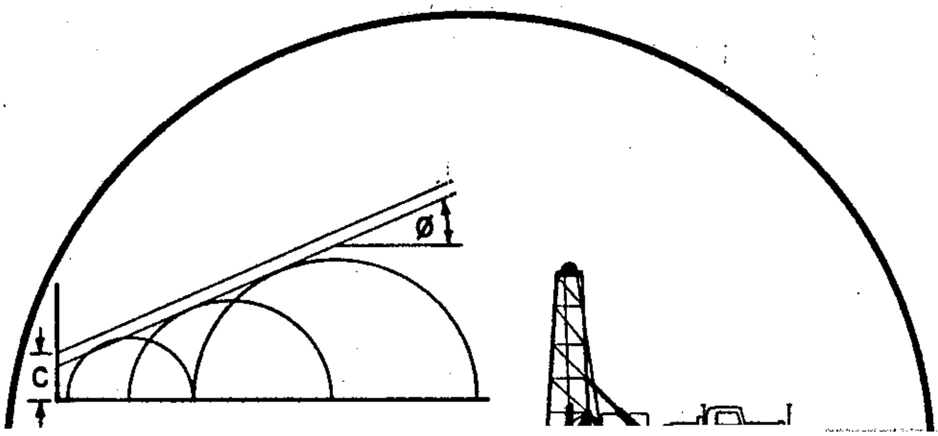
TRANSPORTATION LABORATORY



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SLIDE INVESTIGATION

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STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF STRUCTURES & ENGINEERING SERVICES
OFFICE OF TRANSPORTATION LABORATORY

September 1, 1976

ERFO 781(1)
03-G13-Forest Highway 7
(Mendocino Pass Road)
Lab. Auth. 662797

Mr. Jerry L. Budwig
Director, Office of Federal Highway Projects
Federal Highway Administration, Region 8
Denver Federal Center
Denver, Colorado 80225

A-446 Landslide
A-542 Landslide [illegible]
A-830 [illegible] [illegible]
B-61 [illegible]

Through Mr. Omar L. Homme, Division Administrator

Dear Mr. Budwig:

Submitted for your consideration is:

REPORT OF SLIDE INVESTIGATION
AND GEOLOGICAL REVIEW NEAR STATION 273±
03-GLE-FOREST HIGHWAY 7
WEST OF WILLOWS, CALIFORNIA

Study made by . . . . Geotechnical Branch

Under the General Direction of . . . . . . Raymond A. Forsyth

Work Supervised by . . . . Joseph B. Hannon

Report by . . . . Joseph B. Hannon and
Duane D. Smith

Very truly yours,

George A. Hill

GEORGE A. HILL
Chief, Office of Transportation Laboratory

Attachment

cc: O. L. Homme, FHWA, Sacto
G. Wishman, FHWA, Sacto
J. Walkinshaw, FHWA, SF
A. C. Estep, DOT, Local Asst.
G. A. Hill, DOT, Translab
H. L. Payne, DOT, District 03
L. V. Blackburn, DOT, Dist. 03
Rec'd. DRAFT COPY:
J.M.Ellis, Jr., FHWA, Colorado
Fondedile Company, Cambridge, Mass.

JBH:lb

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INTRODUCTION

This report is the first of a series of three that will present the results of geological review and slide investigations performed at various sites on Forest Highway 7 (Mendocino Pass Road) located in Glenn County, west of Willows, California (Refer to Sheet 2). Their common purpose is to determine the feasibility of utilizing Fondedile Root Piles to correct the slope instability problems that exist on this facility and to consider other alternatives for correction. These locations were selected on April 8, 1976, during a field review conducted by personnel representing both FHWA and the Caltrans Laboratory. It was tentatively agreed that Caltrans would investigate these sites for feasibility of a Fondedile correction under an amended version of a previous agreement.

Forest Highway 7 has been the subject of various field reviews by County, State, and Federal agencies over the last four years due to storm damage in numerous unstable areas. Maintenance has become an ever increasing problem.

The various areas of instability of this project provide the opportunity to evaluate a proven European technique for increasing slope stability. FHWA is interested in the potential of the Fondefile system, also referred to as "Reticulated Pali Radice" or "Root Piles", as a possible alternative slope stabilization technique on Federal facilities. A previous investigation by Caltrans reported February 9, 1976, was conducted for a proposed experimental installation at Station 418. However, it was determined that instability at this particular location could be corrected more economically by a solution other than the Fondedile technique.

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Based upon a field review of the Forest Highway 7 project on July 8, 1976, Dr. J. R. Sallberg of FHWA headquarters concurred that the three slides selected for the study had potential for correction with Fondedile piles. He also concurred on the desirability of an instrumentation and performance study of Fondefile root piles if that technique was employed at one of these sites.

The information in this report pertains to the investigation of the sidehill embankment between Stations 271± and 276±. This location appears to be the most challenging for the Fondedile correction. Additional site investigations will be covered in subsequent reports.

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SITE GEOLOGY

The site of the slide under investigation between Stations 271± and 276± is located near the eastern edge of the Coast Ranges Geomorphic Province of California. This province consists of many separate ranges, coalescing mountain masses, and several major structural valleys.

Two entirely different basement complexes, one being the Jurassic-Cretaceous assemblage called the Franciscan Formation and the other consisting of Early(?) Cretaceous granitic intrusives and older metamorphic rocks, are present in this province.

The area of study has been mapped by the California Division of Mines and Geology as part of the Franciscan Formation. Geologic units mapped on the site by our department, however, are not the typical graywacke, shale, chert and conglomerate of the Franciscan but rather are characterized by metasedimentary rocks consisting predominantly of phyllite with secondary mica-quartz schist and slate. These rocks may be metamorphased Franciscan rocks, but are more probably part of an older basement complex mapped in adjacent areas as "Pre-Cretaceous Metasedimentary rocks".

Intermediate in metamorphic grade between slate and schist, the weathered surficial outcrops of phyllite display a rich golden silkly sheen on the surface of cleavage or schistosity and have a greasy feel when rubbed with the hand. Unweathered phyllitic core samples taken below the water table were dark blue-gray, with all gradations in color from the capillary fringe to the outcrops on the surface.

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Interbedded with the phyllite are scattered thin layers of mica-quartz schist which are light to dark gray in color and are much harder than the phyllite. Local pods and veins of quartz are common, along with numerous zones of highly sheared and pulverized phyllite which take on the characteristics of clayey gouge.

The slide mass itself is composed of a mixture of reddish-brown clayey soil and rock fragments of the parent phyllitic and schistose bedrock.

Excellent exposures of the bedrock are visable on either side of the slide in the cut slopes. Here the thinly bedded meta-sediments display severe folding, faulting and fragmentation. This distortion is probably related to ancient movement along the major northwest-southeast trending Stony Creek Fault lying approximately four miles to the east.

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DESCRIPTION OF SLIDE

Forest Highway 7 crosses the middle of an old landslide in the vicinity of Sta. 271 + 75 to 275±. Examination of aerial photos taken on October 10, 1964 during clearing and grubbing operations for the new alignment shows the main scarp to be located approximately 200 ft. right of centerline. The toe of the old slide may extend to Rattlesnake Creek at the base of the steep hillside (see attached Sheet 3).

Renewed movement occurred during the wet season of 1973. Cracks progressed up the cut slope and into the dense brush for a total distance of approximately 160 ft. right of centerline. The main,, arcuate shaped scarp is 5 to 6 ft. high with some cracking above it.

Movement on the downhill side also occurred with subsequent displacement of the roadway and sidehill embankment. Cracking and push outs of loose material can be observed for a distance of approximately 200 ft. down slope (see attached plan, Sheet 3).

Guardrail for some 100 ft. left of centerline has dropped a few feet and is partially suspended in the air. The underdrain which crosses the roadway near Sta. 273+60 was still functional. The out flow of this underdrain has deeply incised the steep hillside by the erosive action of runoff.

It appears that failure was precipitated by saturation of old, loose slide debris forming the 20 to 30 ft. high cut slope and the embankment foundation. Removal of lateral support by cutting undoubtedly contributed to the renewed instability.

A somewhat flat, amphitheater shaped area below the main scarp and above the top of cut serves as a catchment area for runoff, contributing to the saturation of the slide debris.

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SITE INVESTIGATION

Field mapping of this slide began on May 6, 1976, by an engineering geologist of this department. Based on this geologic reconnaissance two borings were made, the location of which are shown on Sheet 3.

Drilling began at Boring D-1 on June 29, 1976, using a Failing 1500 drill rig and a crew of three drillers. An engineering geologist logged the boring. Continuous samples were taken using the 2-inch Modified California Sampler from the surface to refusal at 13 ft. From this level to the bottom of the boring at 55 ft., a 5 ft. Longyear core barrel with carboloy bits was used continuously. Groundwater was recorded at 36.5 ft.

A description of the materials encountered during the drilling operation is shown on the boring profiles (Sheets 1 and 4). Two soft, highly sheared, clayey gouge-like zones were noted at 13 and 45 ft. in boring D-1 and are thought to represent planes along which movement has occurred.

Boring D-2 was drilled, sampled and cored to a depth of 40 ft. An attempt was made to sample those soft zones which were encountered in Boring D-1 (Refer to Sheet 4). No representative samples could be obtained from the soft shear zones. Groundwater was encountered at the 31.2 ft. depth in this boring.

A slope indicator (S.I.) was also installed to monitor movement of the slide. The initial reading was taken on July 30, 1976, and the first follow-up measurement was made August 5, 1976. No movement was indicated during this time period. It appears the slide has stabilized for the interim but movement is highly probable with added lubrication of the slide mass. Subsequent readings will be made throughout the wet season to monitor any future movement. However, corrective action should probably be done prior to this winter season in order to prevent complete failure at this location.

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FAILURE ANALYSIS

A slope stability analysis was performed using a cross-section at Station 273+50 provided by FHWA (Refer to Sheet 4). Since representative samples from the probable shear zone were not available for testing, the Soil X computer program technique was used to fit a failure arc to the assumed plane of movement. This zone was established from the geologic review and the boring logs. The process consists of assuming soil shear strength parameters which will yield a factor of safety of unity for the probable failure arc. For this condition, the groundwater table was also assumed to be elevated approximately 10 ft. above the indicated July 23, 1976 level. The soil strength parameters satisfying these conditions at failure were $\phi = 13°$ and c = 500 PSF. Slope geometry, boring logs and location of the probable failure surface are shown on Sheet 4.

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CORRECTION ANALYSIS

The following three alternate treatments are suggested as possible measures that could be applied to correct the instability that exists between Stations 271± and 276±:

1. Remove slide debris from cut slope above roadway. This could be accomplished by widening some 20 ft. at grade and using a variable cut slope from the edges of the unstable area to a maximum of 2:1 in the center of the slide as shown by attached Sheet 4. Positive drainage should be provided at grade to conduct the surficial water away from the slide area. This treatment would provide unloading of the slide and prevent surface water from ponding and entering the slide mass near the upper scarp. As part of this correction, horizontal drains could be drilled inward from locations adjacent to the lower periphery of the slide. More positive drainage could be achieved by constructing a 100 ft. length of cutoff trench 40 to 45 ft. right of centerline to a depth of 30 to 35 ft. The trench would be backfilled with permeable material with the upper 3 ft. depth sealed with native material to prevent infiltration of surface water. Water could be removed by means of an outlet pipe or intercepted by horizontal drains. This "deep trench" type of drainage installation was recently used successfully for the correction of a continuing slide problem on Interstate Route 80 near Vallejo. A tractor mounted backhoe with a digging capability to 34 ft. depth, opened the excavation with permeable material being placed immediately behind. Since no pipe was placed and so little of the excavation was opened at any given time, it was not necessary to use shoring, which, of course, would have made the price prohibitive. As would be the case for all three alternates, the down slope portion of the slide mass should also be dressed

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and sealed to improve drainage and prevent saturation and erosion at the toe. The effect of the unloading as indicated by the stability analysis referred to earlier increased the factor of safety from unity (F.S. = 1.0) to F.S. = 1.18. When the water table is lowered to the July 23, 1976 level by dewatering and is combined with unloading, the factor of safety increases to 1.24. No additional instability is anticipated on the cut slope, if all loose material from previous movement is removed by unloading. This alternate would probably be the most economical of the three.

2. The second alternate would require a detour and would consist of removing the existing slide mass and constructing a stabilization trench keying into firm material and providing subsurface drainage by means of a permeable blanket and outlet trench. The approximate location and general detail of the stabilization trench is shown on attachement Sheet 4. This solution has a degree of risk since it would remove lateral support for the upper portion of the slide mass. When constructed, however, it would be quite effective since it would provide positive drainage and a shear key into relatively competent material.

3. The third solution involves the construction of a Fondedile reticulated pile structure founded below the slip plane. This particular slide appears to be the most active of the three studied. However, the location of the slip plane may require pile depths in excess of 50 ft. Drilling at this site will be more difficult than the other locations and will probably require a rock bit rather than a soil auger.

The feasibility and design of this correction will be determined by Warren-Fondedile, Incorporated of Cambridge, Massachusetts. A copy of this report will be forwarded to their office for

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information. A proposal for construction instrumentation and performance of this system will be prepared by the Caltrans Laboratory in the event that Alternate 3 is selected as the remedial measure.

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INSTRUMENTATION PROPOSAL FOR FONDEDILE PILE INSTALLATION ON FOREST HIGHWAY 7

INTRODUCTION

The Federal Highway Administration has recently encouraged various state highway agencies to study the Fondedile pile system for stabilization of slopes. Dr. Sallberg of FHWA Headquarters visited the FH-7 Project in July 1976. Based upon this review, he indicated that at least one of the three sites being investigated may be suitable for correction using the Fondedile technique. If this is confirmed by the results of the ongoing investigation, it is suggested that a minimum of five (5) piles within the proposed Fondedile Pile system be instrumented during the construction operation. This instrumentation can be used for control and long-term performance evaluation.

The proposed instrumentation work to be financed as part of construction control would consist of purchase of instrumentation, laboratory installation and calibration of instrumentation, field installation and initial monitoring. No data analysis or reporting would be conducted under this contract agreement. A follow-up HPR study would be utilized for subsequent monitoring of instrumentation, load testing and test of pile system response, analysis of data, establishment of design criteria and reporting. The HPR proposal is attached for information. It will be submitted for approval through normal research channels, if the construction instrumentation plan is acceptable.

SCOPE

The proposed instrumentation plan for construction control consists of instrumenting five (5) preselected piles and providing

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additional slope indicator monitoring locations and both horizontal and vertical survey points. Four (4) strain gages will be installed on the circumference at the 90 degree points on the reinforcing steel bar of each test pile at three elevation levels. Carlson M-4 Strain Meters will also be installed at the same levels and locations by means of a special jig attached to the reinforcing bar. These special jigs will hold the strain meters in position at a distance sufficient to provide approximately 1-inch of concrete cover between the outer nominal pile diameter and the strain meter. Load cells will also be welded to the bottom of each reinforcing bar of the five (5) test piles. The instrumented bars will be installed prior to concrete placement.

Load cells will be installed at the top of each instrumented reinforcing bar by means of a special attachment and grouted into the cap beam. All instrumentation wires will be routed to an instrumentation readout facility. A schematic of the proposed instrumentation plan is attached.

COST ESTIMATE

I. Purchase of Instruments

1. Strain Gages

   5 piles x 3 levels x 4 gages = 60 gages
   60 gages @ $15 ea. = $ 900

2. Carlson Strain Meters (M-4, 5/8-inch diameter x 4 inches long)

   5 piles x 3 levels x 4 meters = 60 meters

   60 meters @ $40 ea. = 2,400

3. Load Cells (Laboratory Fabricated)

   5 piles x 2 cells = 10 cells
   10 cells @ $500 ea. = 5,000

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4. Slope Indicator Casing

2 installations x $300		600
Total		$ 8,900

II. Laboratory Installation and Calibration of Instruments

1. Strain Gages

60 gages x 4 M.H./gage x $30/Hr.	=	$ 7,200

2. Carlson Strain Meters

60 meters x 1 M.H./meter x $30/Hr.	=	1,800

3. Load Cells

10 load cells x 2 M.H./load cell x $30/Hr.	=	600
Total		$ 9,600

III. Field Installation of Instruments

1. Strain Gages

60 gages x 2 M.H. x $30/Hr.	=	$ 3,600

2. Carlson Strain Meters

60 meter x 4 M.H. x $30/Hr.	=	7,200

3. Load Cells

10 cells x 2 M.H. x $30/Hr.	=	600

4. Slope Indicators

2 indicators x 25 M.H. x $30/Hr.	=	1,500

5. Survey Monuments

20 M.H. x $30/Hr.	=	600
Total		$13,500

IV. Initial Instrumentation Monitoring

40 M.H. x $30/Hr.	=	$ 1,200

V. Travel Expenses

Field Installation and Monitoring

Per Diem 60 M.D. x $35/day	=	2,100

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VI.	Equipment		
	Miscellaneous Vehicles		300
	Drilling Equipment		300
	Truck for Instrumentation		300
		Total	$ 900
VII.	Materials (Plugs, cable, wire, misc.)		$ 800
VIII.	Engineering Supervision		
	100 M.H. x $30/Hr.		$ 3,000
		Grand Total	$40,000

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SUMMARY OF ESTIMATED COST

		MAN HOURS	COST
I.	Purchase of Instruments	--	$ 8,900
II.	Laboratory Installation and Calibration of Instruments	320	9,600
III.	Field Installation of Instruments	450	13,500
IV.	Initial Instrumentation Monitoring	40	1,200
V.	Travel Expenses	--	2,100
VI.	Equipment	--	900
VII.	Materials	--	800
VIII.	Engineering Supervision	100	3,000
	TOTAL	910	$40,000

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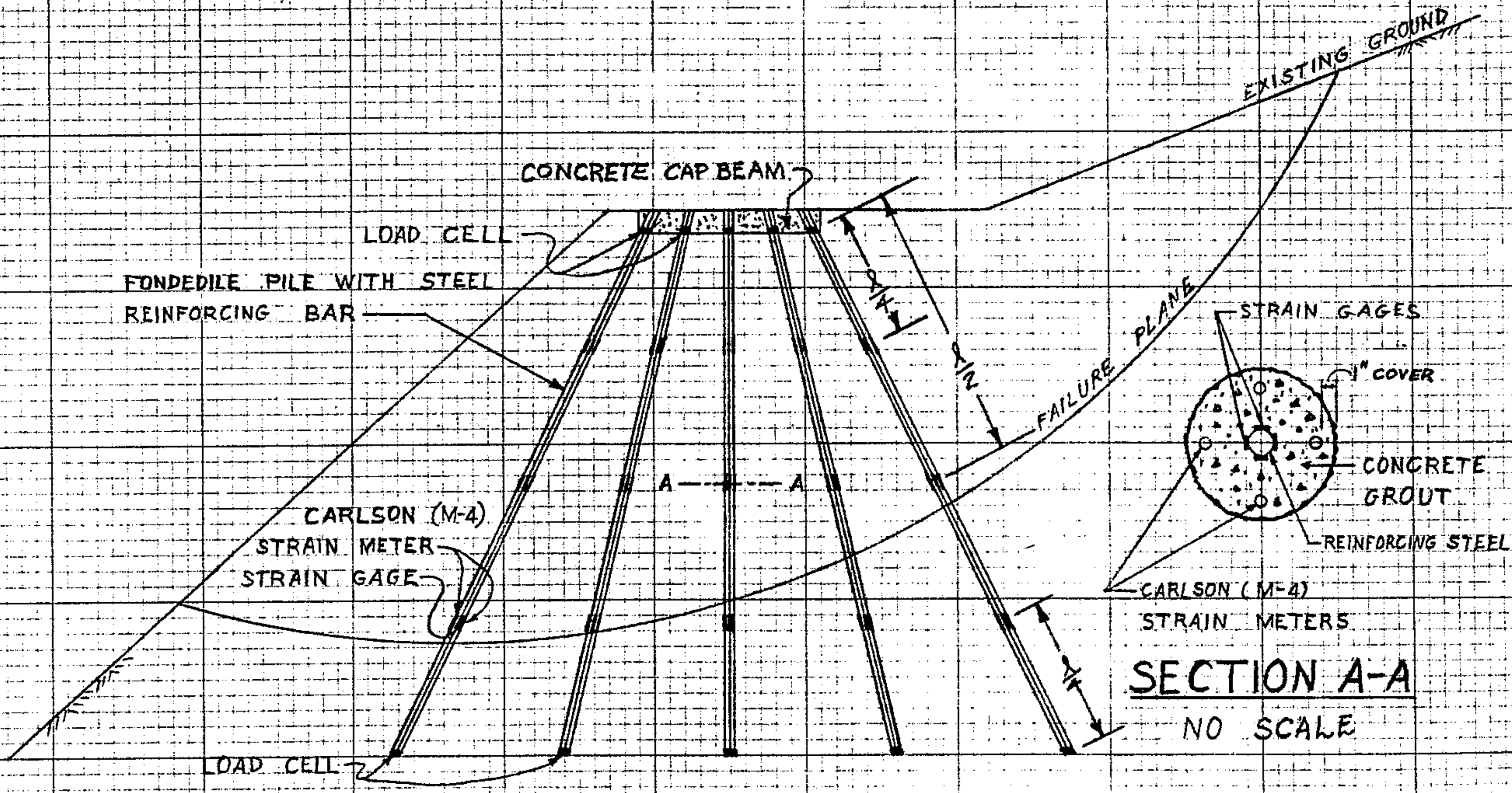
SCHEMATIC OF PROPOSED INSTRUMENTATION FOR FIVE PILES



SECTION A-A

NO SCALE

TYPICAL SECTION

FONDEDILE PILES

NO SCALE

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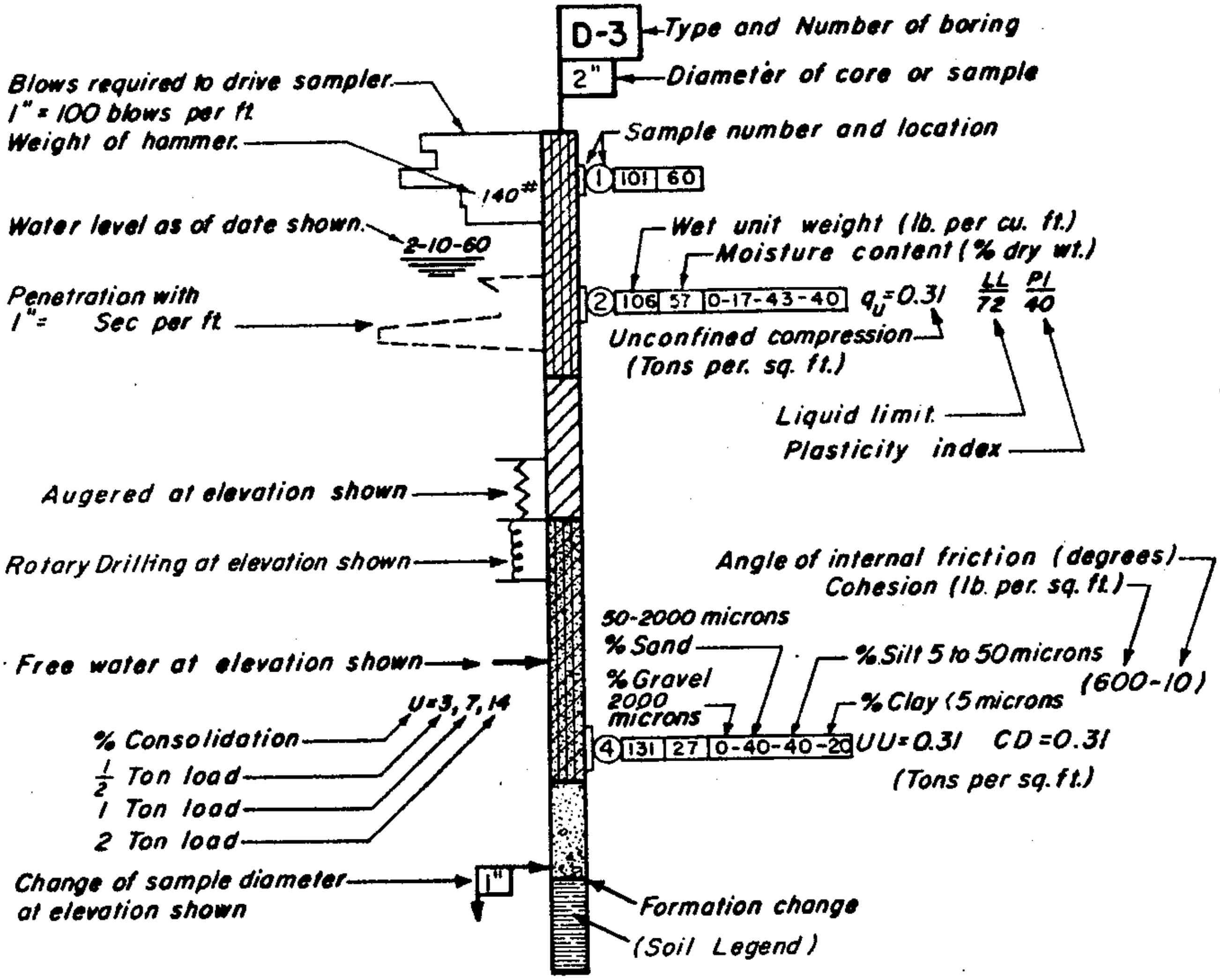
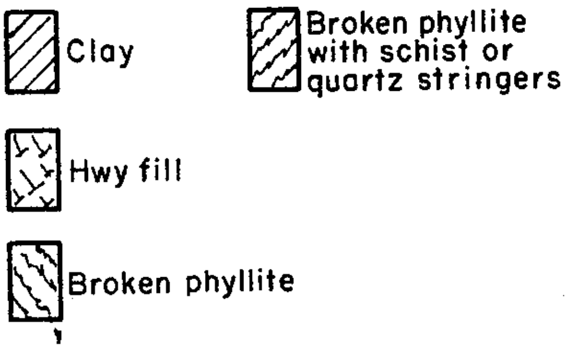
BORING LEGEND
CROSS-SECTION & PROFILE SHEETS



SOIL LEGEND



STRENGTH TESTS

q_u - Unconfined Compression
UU - Unconsolidated Undrained
CU - Consolidated Undrained
CD - Consolidated Drained

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LANDSLIDE INVESTIGATION
FOREST HIGHWAY 7
BETWEEN WILLOWS & COVELO

DATE		SUBMITTED BY:	DWG. NO.
6 Aug 76		Joseph Hannon, SR. MAT'LS. & RES. ENG'R.	2797
DR BY	CK. BY	APPROVED BY:	SHEET NO
		CHIEF, GEOT. BR.	1 OF 4 SHTS.

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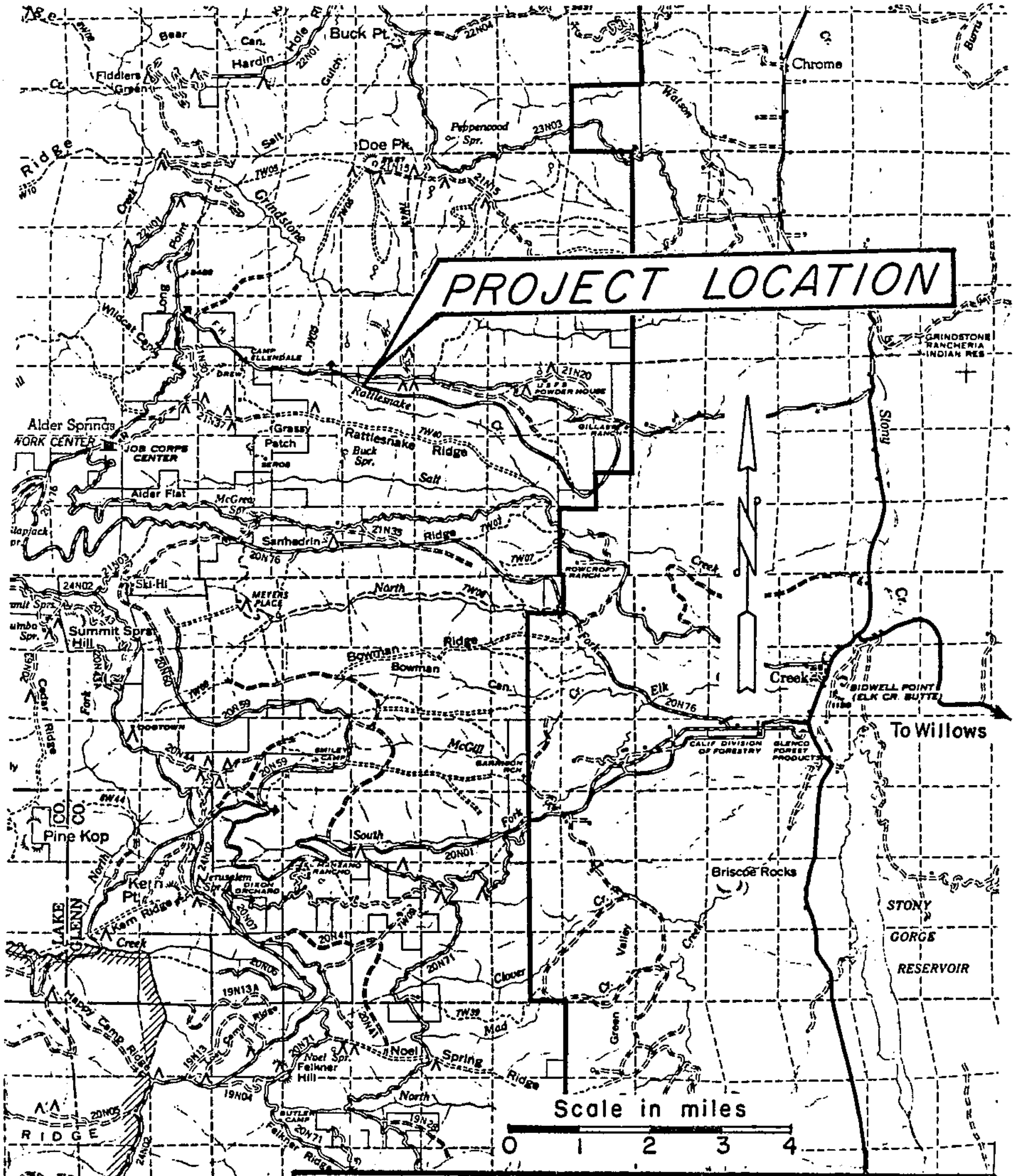

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LANDSLIDE INVESTIGATION NEAR STA. 273±

DATE	DIST	COUNTY	ROUTE	POST MILE	DWG NO.	TOTAL SHEETS
6Aug76	03	Gle	FH7		2797	2 of 4

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